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Practical experiences of demand side integration through pricing

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SUMMARY

The unbundling of the electricity market requires new business models and new integrating technologies to optimize the economy of the whole value chain. To realize the Europe-wide electricity network of the future, a crucial ingredient is an open, universally accessible and standardized ICT communication infrastructure. All market participants shall be provided with required information without discrimination.

Automated Smart Meters, which automatically transmit information on electricity consumption, will be installed in customer households. The paper describes the general technical and organizational requirements and results of an extensive trial of remote reading from household meters.

The paper introduces Minimum Emission Regions (MeRegio). MeRegios, are areas possessing energy supply systems that are optimized with respect to their greenhouse gas emission. In particular, electric and thermal energy should be produced, transported, and consumed efficiently using low-emission power plants as well as Smart Grid innovative functions and components. The following projects show solutions for the establishment of new technologies enabling a higher flexibility on the demand side.

The paper presents the latest results of selected research projects in Germany. The main focus is practical knowledge gained from the projects and the effects of new pricing models on energy conservation and load transfer.

KEYWORDS

Smart Grid, Smart meter, E-Energy, MeRegio, Web2Energy, Dynamic tariff, Powerline, IEC 61850, Storage

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Project Mulheim counts: 100,000 smart meters for the city of Mulheim (Ruhr)

Between July 1, 2008 and December 31, 2011, a total of more than 100,000 automated Smart Meters, which automatically transmit information on electricity consumption, will be installed in Mülheim's power network.

Roles in the deregulated metering market in Germany
The German legislature has established a complicated structure for the sampling operation. In the case that the customer will not accept the offer of the DSO he has the opportunity to choose a special meter operator and meter data service provider (Fig. 1).

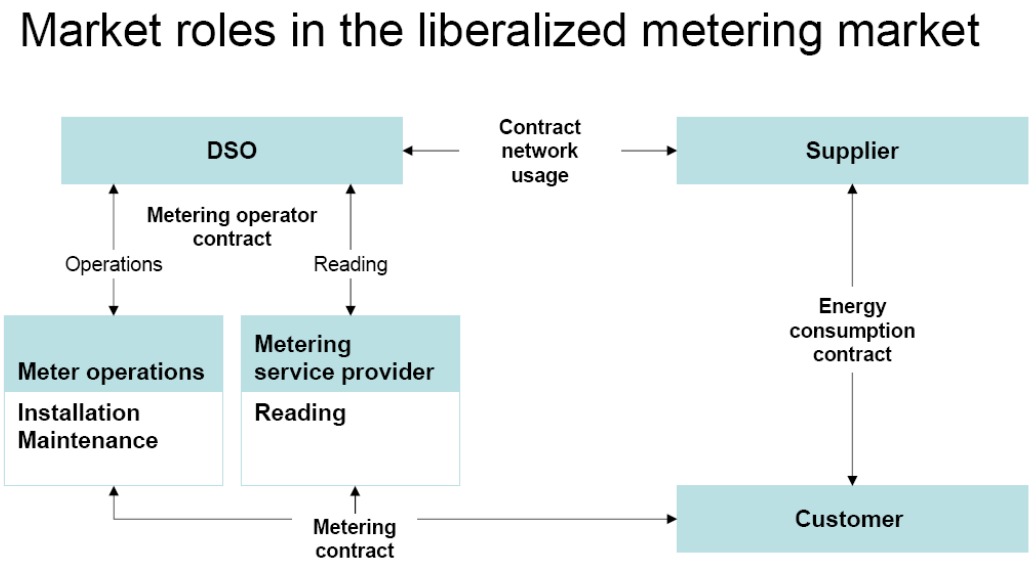

Fig. 1: Market roles in the liberalized metering market

This complicated structure and the uncertainty of a lack of investment security are reasons that neither supplier nor DSO lead them to introduce a new and complex meter technology. The legislature expects that more and more customers will prompt to ask for new meter technology and that this will lead the customer-driven process in the coming years to constitute a complete installation of smart meters. Moreover, the legal requirements for smart meters are expressed only in very general terms. The customer should receive timely information about his energy consumption, so that this will excite to energy savings.

Currently there are no uniform requirements for the necessary functionality of smart meters. Even now there are no multi-vendor open standards for the meter data communication. Meanwhile, the display of energy and other sensitive information on electricity meters has led to an extensive discussion of the necessary of data protection. Additional technical measures at the meter must be provided to prevent the reading of additional consumption information by third parties.

The aim of the project
RWE Energy has taken note of this situation in 2007, the decision to test the possibilities and limitations of smart meters and promote the further development of technical standards within the meaning of open interfaces and a changeability of meters and associated communication devices too. To examine all the technical, legal and organizational fields, the city of Mulheim (Ruhr) should be equipped with more than 100,000 new electricity meters to the end December 2011. This will be done in various phases of the project, in which different technologies (PLC, GPRS, radio) for the transfer of

the metered data will be used. Responsible for the project is the local RWE Rhein-Ruhr distribution network operator.

In phase 1, from July 1st, 2008 to June, 30th, 2009 nearly 14,000 electricity meters have been installed with integrated PLC modules. These meters and their associated PLC concentrators do not have open communication standards. The aim of this project phase 1 was to gather first experience with PLC communications, to build an IT-infrastructure for the collection and provision of consumption data and to learn the reaction of customers. In the now ongoing project phase 2 new meters and communication modules will be tested, together with a new PLC-modulation method.

Equipment Engineering
To meet the requirements of all market participants (DSO, supplier, customer) in the German market model, RWE has opted for a modular solution of electricity meter and a separate communication module (multi-utility communication controller = MUC). For the communication between meter and controller (primary communication), communication between controller and data concentrator (secondary communication) and communication between controller and home display (tertiary communication) open standards are now available (Smart Message Language SML). So in future, the combination of items from different manufacturers is possible. Since September 2009 these new device standards are now incorporated in the project phase 2 (Fig. 2).

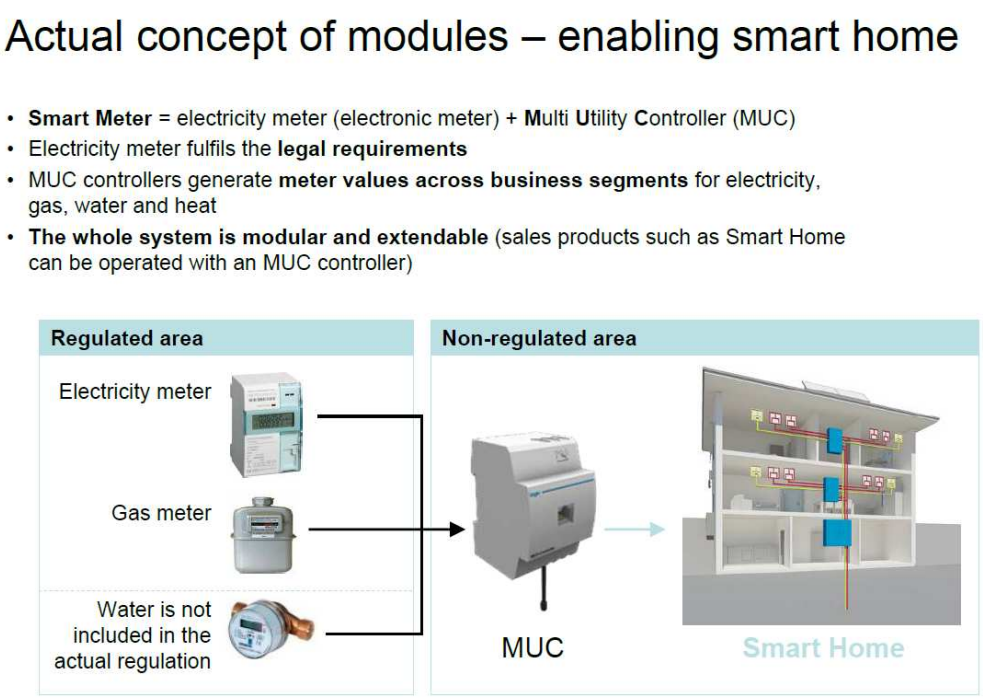

Fig. 2: Concept of modules (meter and communication controller)

System Architecture
The system architecture uses MUC with SML as a core element. Different communication channels have no impact on the OSI layers as the hardware used is independent of the ways of transmission. Thus, the condition is met that the metered data can be used as part of Smart Grid and Smart Home applications in future.

Experiences
After installation of meters and data concentrators in about 1% of the customer premises were found that customer-owned equipment (touch lights, stoves, clocks) comes in interference with the powerline signals. These faults could be eliminated by the use of filters.

The Data Protection Act currently allows the reading and provision of monthly meter reading. Only if the customer gives written consent, may also be done more frequent readings or load profiles may be recorded. Currently, the customer can view the monthly consumption rates on an internet platform. The interest of the customer to the consumption rates has been relatively low until now.

Outlook
The new device technology that is currently installed, allows the customer to collect an online view the consumption data via an in-house communication. In addition, customers need special software that has to be installed on the customer's PC. The in-house data transmission via the tertiary communication from MUC controller to the PC uses a broadband PLC-communication.

With these components written above we are sure to meet the legal requirements and bring sufficient information to the customer for enabling him to steer and reduce his energy consumption. We step forward in building first components for the vision of smart grids and smart home.

Project MeRegio (Minimum Emission Region)

E-Energy: ICT-based Energy System of the Future
E-Energy is a priority support and funding program of the Federal Ministry of Economics and Technology (BMWi) as part of the strategic technology policy of the German Federal Government. The primary goal of E-Energy is to create E-Energy model regions that demonstrate how the potential for optimization presented by information and communication technologies (ICT) can best be tapped to achieve greater efficiency, supply security, and environmental compatibility (vertices of energy and climate policy) in power supply, and how, in turn, new jobs and markets can be developed. The particularly innovative approach of this program is that integrative ICT system concepts optimizing the efficiency, supply security, and environmental compatibility of the entire electricity system along the supply chain, are developed and tested in real-time in regional E-Energy model projects.

Overview
In 2007 the European Union set up the so-called “20/20/20” energy target: Until the year 2020 a 20% reduction of CO_2-emissions based on 1990 levels, a 20% higher efficiency in energy consumption, and 20% of primary energies should be achieved with respect to renewable energies. In this context, the project “MeRegio – Minimum Emission Region” was set up in the course of the “E-Energy Program” with the objective to develop regions with power supply systems that are optimized with respect to their greenhouse gas emissions. The project’s approach is mainly based on three components, namely

- E-Energy marketplaces, which bring together all energy market roles (e.g. utilities, owners of DER, end customers, and intermediaries) for an efficient allocation of energy and system services;
- an innovative technical energy infrastructure (smart grid), which provides the foundation for future proliferation of DER and the development of pervasive demand side management;
- and a powerful information and communication infrastructure that links the physical infrastructure to the marketplaces, which allows to operate the infrastructure according to the specific market situation at hand.

The project focuses on developing technical and economic concepts, which implement the three components and puts them to work in a “real” pilot region with 1.000 participants in the areas of Göppingen and Freiamt (Baden Württemberg / Germany). Furthermore, the project plans to develop a minimum emission certificate for the regions using new specifications and standards based on the experiences gathered in the field test. At the end of the project this certificate is planned to be available for all regions which actively reduce their greenhouse gas emissions.

The interdisciplinary project team combines the expertise of five chairs of the Karlsruhe Institute of Technology (KIT) and several considerable industrial partners: EnBW (having the project lead), ABB, IBM, SAP, and Systemplan. The industrial partners focus on the business context applicable to the field trials and the implementation of new Smart Grid and IT technologies as well as standards and standardization (like dynamic tariffs, the trading marketplace or new applications in the network control system). The KIT, however, is mainly involved in the analysis, simulation, and development of concepts for each area. The concept phase (resp. the official E-Energy start date) started in October 2008. The project announced the official "real" pilot start by the beginning of November 2009, corresponding private customers are at present equipped with displays showing a fully dynamic tariff. The main components of the project are shown in Fig. 3.

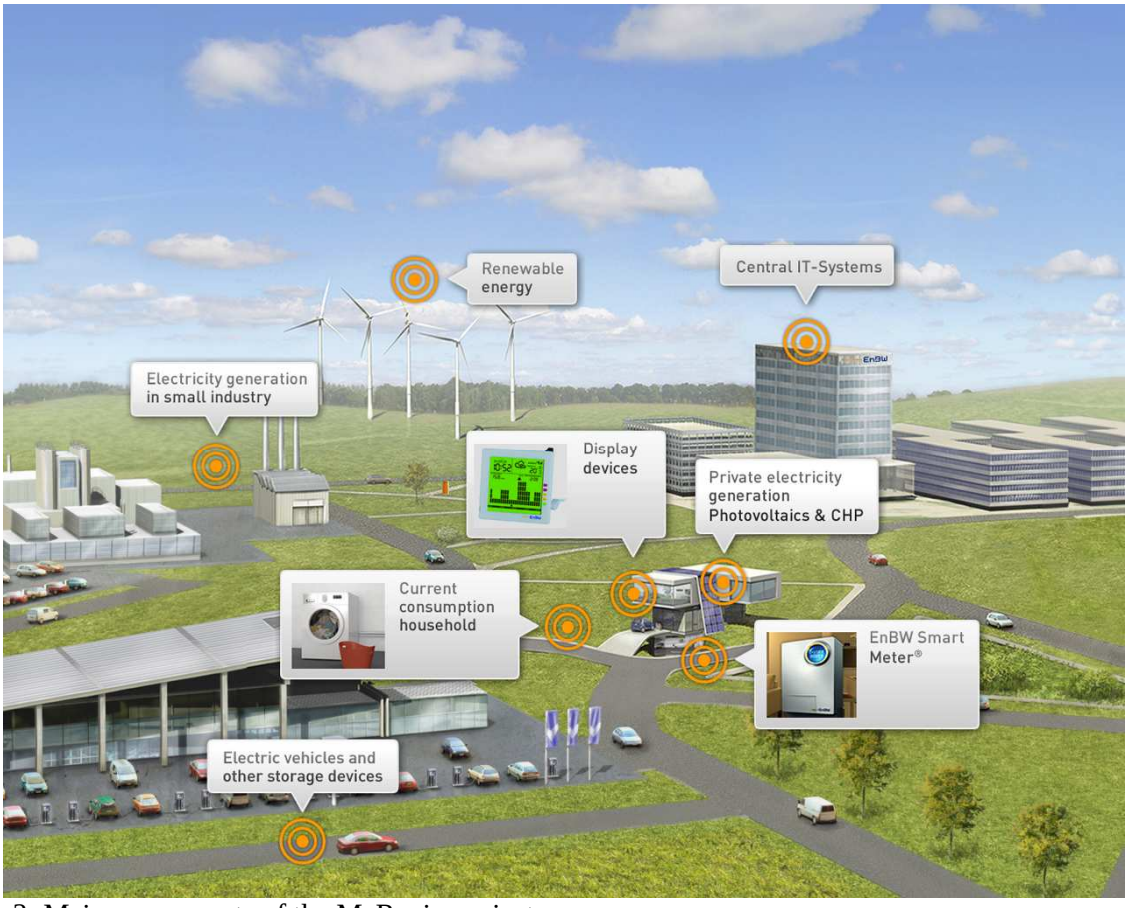

Fig. 3: Main components of the MeRegio project

Integration of multiple distributed resource types

The project integrates conventional power plants, distributed combined heat and power plants (CHP), distributed energy storage systems, as well as renewable energy sources like wind turbines and photovoltaic systems mostly at customer level. In order to integrate these devices and to provide various system services, such as idle load or balancing power, innovative control strategies will be developed and implemented. These strategies will be based on the concepts of liberalized energy markets but will include direct interaction with the network control center to maintain or even increase grid reliability. At the customer level, demand response will be achieved via different regional energy marketplaces for the allocation of energy and ancillary services resulting in dynamic rates, control signals for home appliances, and an overall power management. An awareness of the need for energy-efficient acting will be created in both the population and the (local) politics and economy. Industrial and public (B2B) customers will be consulted specialized on energy efficiency topics and measures in order to boost their efficiency and awareness for saving valuable energy and reducing CO_2 Emissions. Incorporation of Dynamic Rates or other approaches to link wholesale conditions to customers

In the MeRegio project the efficient coordination of energy supply and demand will be developed and tested using 1.000 existing EnBW B2C and B2B customers. Therefore, various marketplaces will be implemented in order to trade energy products and system services. These marketplaces employ different mechanisms to match supply and demand, for example dynamic tariffs that provide an incentive to shift loads, or auctioning mechanisms that can help establish new business models such as aggregators who bundle DERs and resell capacities. At the customer level, demand response will be achieved by dynamic tariffs and control signals for home appliances. On the one hand the dynamic tariffs will be tested according to their benefits along the complete energy value chain (cost-based view). On the other hand, the tariffs will be adjusted to the end-customer's needs (market-based view). In order to understand customer needs, both B2C (household) and B2B (industry and public sector) customers are in focus. For understanding the needs of industrial and public customers, there are consulting and measuring processes, which help the customers to optimize their approach, boost energy efficiency and also save money with their participation on the market. Parallel to the development of the tariffs, control signals ("efficiency and priority signals") are tested, which enable utilities to automatically shift loads adjusting the energy consumption and generation in private households.

Integration into system planning and operations
Within the project, simulation components will be developed and applied to analyze the different design features of the MeRegio concepts. These simulations comprise different market mechanisms, network management concepts and business models as well as tests that cannot be implemented in a real environment, such as power outages or extreme weather events. Long-term effects of a decentralization on the development of the power plant mix will be investigated within an energy system model. Additionally, short-time aspects and their influence on the generation mix will be considered. Power grid simulation tools will be used to analyze the influence of new network control strategies and to identify how additional decentralized capacities can be linked at a certain grid area.

Existing and emerging technologies for DER integration will be applied including a broad range of DER types, communication platforms for smart metering (at B2B and B2C level), and distribution automation. The MeRegio consortium is engaged in a number of standardization boards in the area of smart metering, smart grids, and the adaptation of the legal framework.

An integral part of this project is to create a certificate for minimum emission regions. Additionally, a catalogue of options is designed to improve the energy efficiency of regions and to increase the number of DERs. This certificate will create awareness of the need for energy-efficient acting. In addition, the certification will enable the comparability of regions.

Project Web2Energy

Overview
Within the scope of the seventh framework programme of the European Commission HSE and nine partners developed the project Web2Energy (W2E). The project aims to develop an open, universally accessible and standardized ICT communication infrastructure. The key idea is the consistent, homogeneous and uniform application of globally accepted IEC standards, specifically for Communication protocols (IEC 61850), ICT network security (IEC TS 62351) and Database management using CIM (IEC 61968). The W2E project develops the interfaces between all three levels and in this way opens "plug and play" and interoperability capabilities. W2E thus provides a seamless approach to standardisation from the process level, through the ICT infrastructure up to the control centre level.

Field tests will provide and demonstrate the 3 pillars of smart grids:

1. Customer integration: improved efficiency of energy production, to achieve energy savings and reduce peak power demand, for lower system costs and improved embedding of renewable energy resources

2. Active distribution networks: flexible and reconfigurable aggregation and management of distributed secure and unsecure (fluctuating) power sources, storage and controllable loads in virtual power plants, to reach an optimum combination of environmental protection and economical value
3. Self-healing capabilities for the distribution networks based on ICT-enabled response and thus automated fault elimination in MV feeders to increase the reliability of supply

Results will be brought into IEC standardization. Industrial companies in W2E will commercialise the results, including deployment in their whole supply area, and using it as the business model for the near future.

Main innovations

The project will comprise implementation in real distribution system operations including a substantial scale of producers, consumers and network terminals. The control centre has access to a cluster of heterogeneous power sources like:

– Fluctuating Renewable Energy Sources (PV, Wind),
– Energy efficient co-generation plants heat and power (CHP),
– Biomass green gas production,
– Run of the river hydro (2 installations).

A range of smart distribution participants is involved in the W2E field demonstrations – consumers equipped with smart meters, terminals of the 20 kV network, various power producers, controllable industrial loads and storage capabilities. This heterogeneous set of participants ensures that W2E will be able to demonstrate all three pillars of smart distribution systems: customer integration, active networks, and self-healing by automation. This is depicted in Fig. 4.

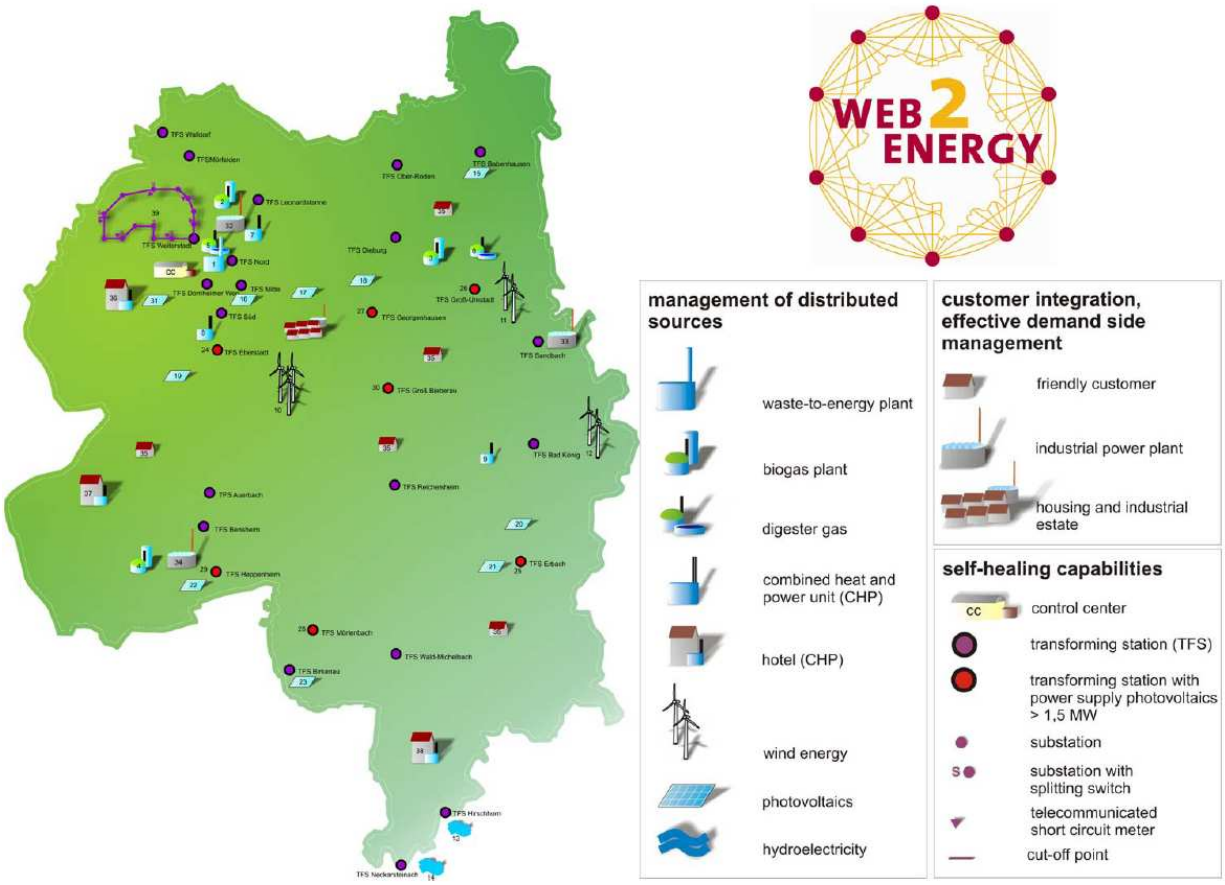

Fig. 4: HSE supply area demonstrating the three pillars of a smart distribution system

The project strengthens the European excellence in engineering by consolidating cross-disciplinary research on energy technologies and ICT. The European industrial and technical position in the global markets of power system applications will be reinforced by the demonstration of such novel ICT solutions and by a permanent interaction and strong impact on the ongoing work for communication standards in IEC.

The experts from the consortium working on the IEC standards will bring the knowledge of the project into the standardization. The W2E solution concepts will be made available as a model for others to use and repeat it. Most of the knowledge will be made publicly available.

The active interaction with the relevant working groups of IEC will be sought for by W2E for several purposes:

- Practical experience with and approval of newly developed standards,
- Improvement of the standards if required,
- Extension of the standards in accordance with the needs detected in the practical applications,

New work item proposals for the development of further standards which are experienced as necessary and still not in the scope of IEC.

Aside from the technical components of the system, this comprehensive research project is examining the effects of special customer rate offers and analyzing the implementation of various storage types. Customer integration into the electricity market by variable tariffs effecting efficient demand-side management and response to improve the efficiency of energy production, to achieve energy savings and to reduce peak power demand, leading to lower system costs and improved embedding of renewable energy sources. It is also the goal of the project to develop innovative tools for prognosis, simulation and planning for the calculation of technical solutions and their economic value. These tools will form the future basis for the development of energy distributors, generators and network operator services.

Various possibilities will be observed in the integration of fluctuating input in the distribution network in order to map these out predictably, guarantee a stable mains operation, and create advantages in the procurement of power. Within this context, the research project is observing a virtual power plant as an approach. The goal is to meet 20% of energy demand with renewable generation plants and distribute energy to the customer according to demand using new storage technologies. Not only is all local input recorded and predicted at the network control center, it is also made available to distributors and service providers so that they can offer the customer incentives through innovative pricing models and also enable customers to make a contribution to the entire system. Various applications of large storage systems in the distribution network and small, stationary storage systems for customers (Partner Packs) will be examined, and possibilities for mobile storage systems (Vehicle to Grid) researched as well. Especially the cities are interested in this project. 10 new housing areas in different cities take part in the project.

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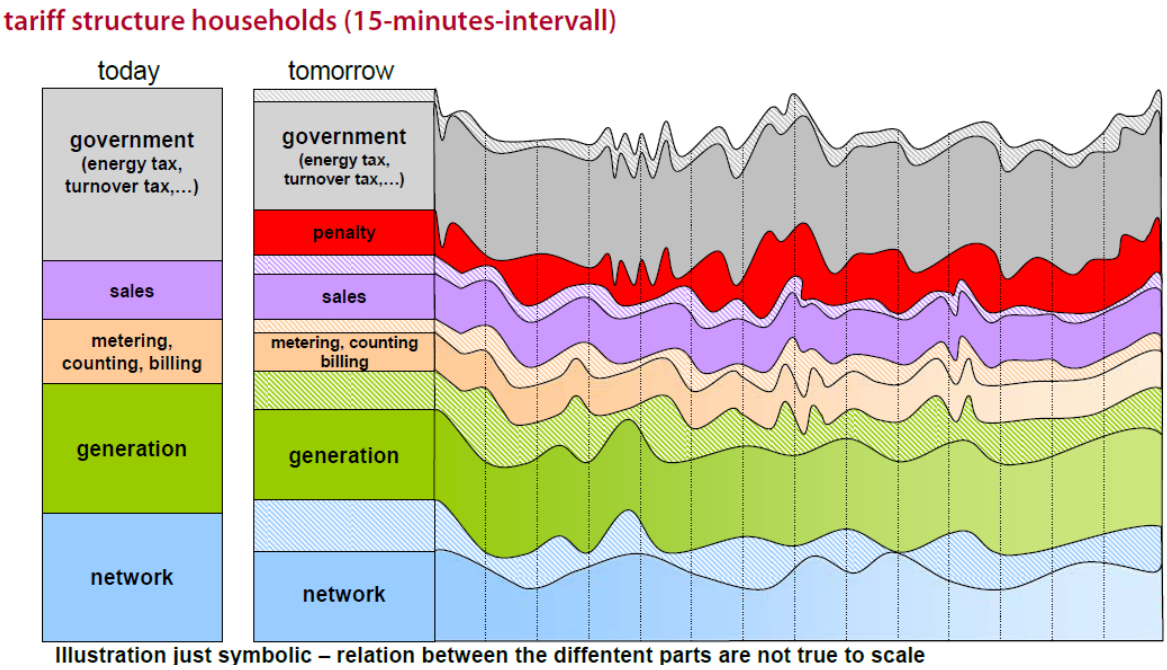
NAME :	B. Fenn	GROUP REF. :	C6
COUNTRY :	Germany	Pref. Subject :	2
REGISTRATION NUMBER :	236	QUESTION N° :	4

Question 2.4

How are the dynamic prices coordinated between the generators, the market operators, aggregators, and the DSO?



The dynamic prices are coordinated by a new market player: The “powermatcher”. The powermatcher has look at the physics [V, A, MWH, MW] and at the commercial parts [€].